Earth Field NMR of porous systems and soils: experimental approach and results

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In this work the transversal and longitudinal relaxation times of the pore water in random packs of glass beads, sintered glass filters and other porous materials are analyzed by Nuclear Induction in the Earth's magnetic field. The measuring device has been developed in-house [1] and is built in a way that it can be used in a normal laboratory environment with disturbances from electromagnetic fields and deterioration of the field homogeneity by steel in reinforced concrete or furniture. Self-compensation against external alternating fields is achieved by a first order gradiometer construction. The temperature of the sample can be varied from –5 up to 60°C (+/- 1°C) by means of temperated air.

The poor sensitivity arising from the low Larmor frequency is compensated by the large homogeneity that permits the use of relatively large samples (25 ml) and by enhancing the initial magnetization by means of pre-polarizing (method of Packard and Varian [2]). The disturbance of the magnetic field in the laboratory is minimized by an appropriate location and by shimming, using three pairs of Maxwell coils. Due to the large field homogeneity it is possible to derive the transversal relaxation times directly from the digitized free induction decay (FID) signal with a signal to noise ratio of about 100 without need for pulse sequences as in conventional NMR techniques. The device is also capable of measuring the longitudinal relaxation dispersion of protons in the range of 3 kHz up to 3 MHz by use of the field cycling technique.

The results for random packs of glass beads and sintered glass filters are fitted to the general model

$$\frac{1}{T_{1,2}} = \frac{1}{T_{1,2b}} + \frac{\rho_{1,2} \cdot \alpha}{r} \qquad (1)$$

and are compared with results from conventional high field NMR applications. The longitudinal relaxation times in function of the Larmor frequency suggest a field dependence of $T_{1,2b}$ at low fields.

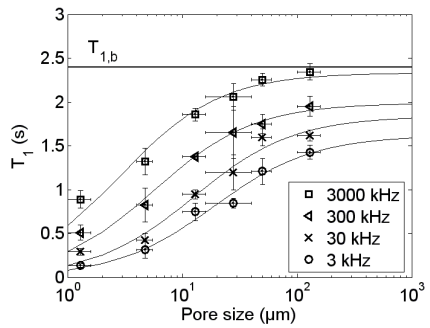

Fig. 1. T_1 in function of the pore size of sintered glass filters for various Larmor frequencies. $T_{1,b}$= T_1 of bulk water.

Equation (1) is used to analyze the pore size distribution of a bimodal porous system. The results are comparable with the pore size distribution derived from mercury intrusion data.

[1] Goedecke, R. *Ph.D. Thesis, University of Bremen* (1993)
[2] Packard, M. and Varian, R. *Phys. Rev.* 93, 941 (1954)